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To: . R. M. Gilman

Date: October 12, 1992

From: . John Rebman

Subject: . Specific Volume Using Helium vs. Nitrogen

Objective:

The objective of this test was to determine the difference between the specific volume results from the Penta-Pycnometer of expanded tobacco at different OV ranges, and to compare the results of helium vs. nitrogen as the displacement gas.

Conclusions:

1. Results of the testing is as follows:

OV, %	Specific Volume, cc/gram				Instrument Errors		Testing Time		Number of Samples
	Average		Std. Dev.		During Testing		(minutes)		
	He	N ₂	He	N ₂	He	N ₂	He	N ₂	
1.3	2.81	2.91	0.08	0.05	Yes	No	17	7	15
1.6	3.05	3.11	0.07	0.04	Yes	No	17	7	15
3.0	3.02	3.05	0.06	0.04	Yes	No	17	7	15
4.8	2.84	2.92	0.04	0.03	Yes	No	18	7	15
6.9	2.13	2.27	0.04	0.04	Yes	No	19	7	15
11.3	1.69	1.80	0.04	0.03	Yes	No	23	9	15

2. The data demonstrated that there is a difference between the means of the SV results using helium and those using nitrogen. The average difference between the two displacement gases is 0.1cc/g with nitrogen results always higher. It is theorized that the SV value is higher with nitrogen because it is not able to penetrate the cell walls of the tobacco.
$$\text{Specific Volume} = \frac{cc_{\text{tob}}}{g_{\text{tob}}} = \frac{cc_{\text{cell}} - cc_{\text{open}}}{g_{\text{tob}}}$$
 As volume of the open area of the cell increases the specific volume result decreases.
3. The average run time with nitrogen is significantly less than with helium.
4. There were no error messages recorded by the instrument while using nitrogen as the displacement gas. This is very important because the new Penta-Pycnometers will not report results if error messages are generated. QA must use nitrogen even if R&D does not.
5. The OV content of the Expanded Tobacco has an effect on the specific volume result. As OV increases the specific volume decreases.
6. Nitrogen is a cheaper displacement gas than helium.

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Recommendations:

1. Use nitrogen as the displacement gas instead of helium.
2. Run tobacco "as-is" and do not dry in the oven prior to analysis. Each SV determination should have an OV value associated with it.

Discussion:

The Penta-Pycnometer is specifically designed to measure the volume and true density of solid objects. An inert displacement gas is used to penetrate the pores and crevices in a sample assuring maximum accuracy. Helium or Nitrogen are inert gases usually used as displacement gases in the Penta-Pycnometer. The manufacturer of the Penta-Pycnometer (Quantachrome Corp.) recommends nitrogen be used when the samples tested are cellulose materials.

The current R&D method specifies that helium be used as the displacement gas. The Penta-Pycnometer using helium produces frequent error messages indicating unstable pressures in the cells of the instrument.

Procedure:

1. Obtain one sample of expanded tobacco of sufficient quantity for the entire test. The OV of the tobacco received was 3.0%.
2. Equilibrate/dry the tobacco at various OV levels. The samples were split and two OV dishes were run from one of the samples and fifteen specific volume results were obtained from the other samples. Approximate levels obtained were 1.3, 1.6, 3.0, 4.8, 6.9, and 11.3%. These samples were frequently exposed to the atmosphere however and the OV level may have changed during the test. The 1.3% level was oven residue following the standard OV test.
3. Analyze the tobacco sample fifteen (15) times at each OV level using helium and fifteen (15) times using nitrogen. The instrument was calibrated before each OV level run and after each gas change.
4. Multiple box and whisker plots of the data are included.

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